XVIII.—*Note on* Bulimulus (Drymæus) citrinellus, *Pfr., and* scitulus, *Reeve.* By Hugh C. Fulton.

B. citrinellus was first published by Pfeiffer in his Monog. Helic. Viv. vol. vi. p. 114 (1868), as a "var.?" of *B. scitulus*, Rve., with the following description:—"Anfractibus paulo convexioribus, strigis spadiceis nullis." The latter part of this is translated in Tryon's 'Manual,' vol. xi. p. 271, as having "no scarlet streaks"; this should have been "no brown streaks." As a matter of fact, specimens which I believe are properly referred to Pfeiffer's *citrinellus* have very pale orange or scarlet stripes, but no brown ones as seen in *scitulus*.

I have before me a large number of both *scitulus* and *citrinellus* collected in 1894 by Mr. Baron, the former at Cajamarca, Peru, and the latter at Cajabamba, Peru. Among the specimens of *citrinellus* are some answering to Pfeiffer's description, whilst others are ornamented with orange and dark brown streaks, so that Pfeiffer's description does not suffice for the material now under consideration. *Citrinellus* is easily separated from *scitulus*; the latter in the adult state is a smaller shell, with much narrower and more numerous streaks, generally narrower in form, with its peristome more contracted at its anterior or basal area, and its whorls increase more rapidly than in *scitulus*, consequently the body-whorl is obviously larger.

Pfeiffer's description of the whorls of *citrinellus* as "paulo convexioribus" is scarcely borne out by the majority of the specimens before me; if there is any difference worth mentioning, I should say the body-whorl of *scitulus* is the more convex of the two, but the specimens vary in this respect.

The darker form of *B. citrinellus* is well illustrated in Tryon's 'Manual,' vol. xi. pl. xlvii. fig. 17; the figure 16 on the same plate is a *not very faithful copy* of the excellent figure of Reeve's *scitulus* as given in the Conch. Icon. pl. xcvii. fig. 513.

XIX. — *Notes on Trematode Parasites of the Cockle* (Cardium edule) *and Mussel* (Mytilus edulis). By William Nicoll, M.A., B.Sc., Gatty Marine Laboratory, St. Andrews.

[Plate IV.]

In April 1903, at the suggestion of Professor M'Intosh, I commenced the examination of the edible cockle (*C. edule*)

for parasitic Trematodes, in the hope of being able to fill up some of the gaps in the life-history of the pearl-forming Distomid of the mussel. The life-history of this parasite (*Leucithodendrium somateriæ*) has been almost completely worked out by Dr. H. Lyster Jameson*. At Piel he found the sporocyst stage in the mantle of the cockle close to the anterior border of the anterior adductor muscle. At Billiers, however, he found the same stage occurring in *Tapes decussatus*. From this we may conclude that the host harbouring the sporocyst stage is not constant, but varies according to locality.

Mr. A. J. H. Russell, M.A.†, at St. Andrews in 1902 (April–July) examined a considerable number of both large and small mussels from the beds at the mouth of the Eden. He found pearls in 45 per cent. of the large, and 21 per cent. of the small mussels. These numbers fall short of those obtained by Dr. Jameson, who found almost every specimen infected. This is probably due to the comparative unsuitability of the locality. Mr. Russell apparently did not determine whether the parasite causing the pearl-formation in the Eden mussels was the same as that described by Jameson, but, assuming this, I sought for the sporocyst stage in the cockle. During three months (May–July) several hundred cockles were examined and in no case were sporocysts present in the positions indicated by Jameson, nor, indeed, in any part of the mantle-edge.

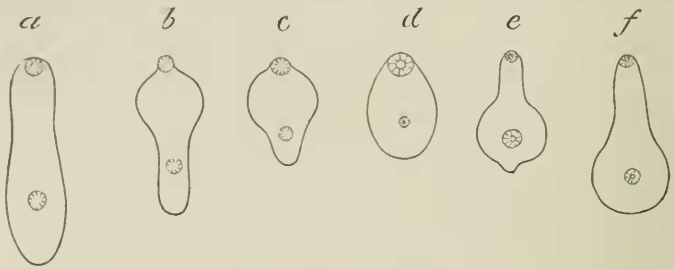
Later, however, in examining the other organs of the cockle, I met with sporocysts containing cercariæ closely resembling those discovered by Jameson in *Tapes*. They occurred in one well-defined, somewhat oval-shaped mass (Pl. IV. fig. 1), situated in the middle line dorsally just over the posterior border of the liver, but separated from that organ by a short distance (1–2 mm.). They could be best seen by removing the cockle entirely from the shell and looking down on it from above. The mass then appeared whitish, semiopaque, and of a somewhat soft consistency. Within it the individual sporocysts appeared as yellow spots of various sizes. The dimensions of the mass were in some cases as large as 4 mm. × 3 mm. The occurrence of the sporocysts in this case is thus different from that observed by Jameson in *Cardium* and more nearly resembles the condition in *Tapes*, for while in the latter large groups were found, "there were only single, triple, or quadruple cysts" in the former.

* Proc. Zool. Soc. 1902, i. p. 140.

† Ann. & Mag. Nat. Hist. 1903, xi. p. 550.

On microscopic examination of a pressure preparation (Pl. IV. fig. 2), the sporocysts contained cercariæ varying in number from two to as many as fifty, while the total number of cercariæ sometimes exceeded 250. Inside the sporocyst they appear of different shapes and sizes, but on being pressed out they assume an oval outline, changing, however, with the movements of the animal.

These movements are interesting. Fully extended (text-fig. *a*), the cercaria is spindle-shaped, and fixing itself in



Movements of cercaria.

this position by its oral sucker it begins to draw the remainder of the body up to the sucker. The anterior part expands (*b*), the rest remaining narrow and elongated, but this is gradually drawn forward until the whole body has the shape of a prolate spheroid (*d*). The ventral sucker then comes into action, the oral is released and the anterior part of the body begins to elongate until finally the spindle-shape is reassumed.

The cercariæ (Pl. IV. fig. 3) vary in size, the average length being about ·22 mm. At the period of greatest contraction the length may be ·11 mm., while at full extension it reaches ·28 mm. The greatest breadth is about ·1 mm.

The whole surface of the cuticle, except on the suckers, is set with small spines arranged in transverse rows, the members of each row alternating with those in the next. Of the two suckers the oral (Pl. IV. fig. 3, *a.s*) is the larger; it is subterminal and cup-shaped, with a circular aperture. The ventral (fig. 3, *v.s.*) is just in front of the bifurcation of the excretory system. The mouth opens in the oral sucker, and viewed from the side it has a triangular outline. It is continuous with a pharynx (*ph.*), the lumen of which has a small dilatation at both ends. The œsophagus is short and divides into two sac-like diverticula (*div.*). The excretory system (*ex.*) occupies the major part of the body. In most

examples it appears intensely black, but in some, the more active and possibly the older, it is lighter in colour. It consists of two wide pouches, uniting posteriorly, continued by a narrow tube, which opens terminally by an excretory pore.

A pair of eyes (*e.s.*) is present, one on each side of the oral sucker. Each consists of a small crystalline rod with a pigment-spot. Round the aperture of the oral sucker are several minute papillæ.

The genital system can hardly be made out in the living animal, but on death, when the tissues become more opaque, a pair of testes (*ts.*) can be distinctly seen, one on each side of, and somewhat behind, the ventral sucker. They contain a mass of globular cells. From each testis a narrow tube issues and joins its fellow from the other side at the level of the sucker. From this point a single tube leads forwards and opens just in front of the sucker.

In addition, in the living cercaria, a number (from 8 to 12) of globular cells (*k.s.*) can be seen in front of the ventral sucker. These may possibly be the rudiments of the ovary.

With regard to the frequency of occurrence of the sporocysts, in a sample of twenty cockles recently examined I found every specimen infected and invariably the sporocysts were situated in the same position. The cockles were not of full size, measuring on an average only 25 mm.

It is evident that, as the cercaria can only perform creeping movements, it must reach its next host in this manner. Search in the mud, however, of the mussel-beds failed to reveal the migratory stage. I have also kept a number of cockles and mussels together in a tank for a considerable time, until, in fact, the cockles died, but met with no better success on examining the mud at the bottom. It is possible that migration may only take place at a particular period of the year.

Although, in the cockle, the mantle-edge was free from sporocysts, it was, nevertheless, by no means free from parasites. In this case the infection took the form of numerous small globular cysts (Pl. IV. fig. 4), as many as 35 being present in one specimen, although, as a rule, the number did not exceed 10. They occurred usually in the inmost fold of the mantle-edge, sometimes in groups of two or three, but oftener singly, and their distribution seemed to be general. They were situated in the loose connective tissue, just underneath the epidermis, but, as far as observed, their presence gave rise to no pathological condition (except that there was a slight proliferation of the cells in the neighbourhood). There was no tendency to pearl-formation round these cysts,

although Herdmann * notes the occurrence of pearls in a number of cockles examined by him, to as large an extent as 8 in 25.

In the foot the same cysts were found in much greater numbers, embedded beneath the epidermis in the muscular tissue. They were most numerous near the tip and were almost entirely confined to the horizontal part. Occasionally white concretions, 2–3 mm. in diameter, were met with in the glandular part of the foot, but these had no obvious connexion with the occurrence of the cysts.

The cysts vary from ·21 mm. to ·25 mm. in diameter. They can be quite easily dissected out from the surrounding tissue. The capsule is perfectly transparent and of a slightly brownish colour. It consists of three parts: the outermost is a thin membrane and is separated from the rest by a space; the middle layer is thicker than the internal, and the whole thickness of the capsule is about ·013 mm. It contains the encysted stage of a Trematode larva. By the use of moderate pressure the capsule can be ruptured and the Distomid (Pl. IV. fig. 5) set free. The anterior part is broader than the rest of the body, somewhat spade-shaped in general outline and with a ridge (fig. 5, *r.s.*), in the form of a horseshoe, bearing spines. The whole length of the animal is ·75–·8 mm. (minimum ·6 mm.). The greatest breadth of the anterior part is ·19 mm., while the rest of the body varies from ·14 mm. in front to ·08 mm. The body is flattened dorso-ventrally.

There are two cup-shaped suckers, raised somewhat above the surface of the body. The oral sucker, situated within the ridge of spines, is smaller than the ventral, having a diameter of ·065 mm. The ventral lies in the middle of the body, but nearer the posterior end, and measures ·095 mm. in diameter. Both suckers have a circular aperture.

The ridge on the anterior end carries 29 spines arranged in a single row. They are about ·025 mm. long, but three at each end are shorter than the others. The ridge has rounded ends and the two terminal spines on each side seem to lie behind and below the adjacent ones.

In addition, part of the body, from what may be called the neck down almost to the level of the ventral sucker, is studded with small hooks (fig. 5, *c.s.*) or spinelets. There are 30 or 40 transverse rows, and the hooks in one row alternate with those in the next, so that diagonal rows are also formed.

The mouth opens in the oral sucker and leads into a

* Lancashire Sea-Fisheries Lab. Rep. for 1903, p. 93.

muscular pharynx (*ph.*) measuring ·05 × ·03 mm. This is continued by a narrow straight œsophagus, which remains undivided until near the ventral sucker, where it bifurcates into two diverticula (Pl. IV. fig. 5, *dig.*).

The excretory system (fig. 5, *ex.*) is well-marked. It is loaded with bead-like globules, which disappear on treatment with acid. There are two main tubes of varying width running almost the whole length of the body and uniting posteriorly in a vesicle which opens terminally by an excretory pore. Anteriorly the main tubes receive numerous short, simple branches.

On more minute examination an extremely narrow tubule (Pl. IV. fig. 5, *f.t.*) can be discerned to the outer side of each main excretory tube. They are provided with flame-flagella and have apparently some connexion with the excretory system, although their exact relation could not be observed.

Genital organs are not yet present, but sperm-cells are apparently developed. They occur diffusely. On rupture of the animal by pressure these cells issue in great numbers. They are evidently spermatozoa, for they possess a head and vibratile tail, and execute the typical spermatozoid movements.

The adult stage (Pl. IV. fig. 6) of this parasite is to be found in the oyster-catcher (*Hæmatopus ostralegus*). I had an opportunity * of examining many of the birds that frequent the shores of the Eden estuary, but in most of them only cestode parasites were to be found. In the oyster-catcher, besides the usual collection of tapeworms, several Trematodes were found in the intestine. The stomach is generally full of the remains of cockles and mussels, and the gut contains numerous cysts similar to those found in the cockle. Towards the lower end of the intestine the desired parasites were obtained. They are not at all of frequent occurrence, but being translucent and of no great size they may easily escape notice.

The adult resembles the encysted larva to a marked degree, the main external point of difference being the elongation of the posterior part of the body. The distance between the two suckers remains practically the same, as does the average breadth of the animal, the whole length being increased to about 1·25 mm.

This parasite has several features in common with the members of the Trematode subgenus *Echinostomum* (cf.

* For this I am indebted to my friends Messrs. R. M. Craig and Arthur Mills and to Mr. A. W. Brown, of the Gatty Marine Laboratory.

E. baculus *, *E. spinulosum* †, *E. echinatum* ‡) ; for instance, the anterior ridge with its spines, which differ only in number and arrangement, and the positions and relative sizes of the suckers. It may be classed under this subgenus and is probably a new species §.

On further examination and dissection of the organs and tissues of the cockle, a number of ciliated sporocysts ‖ (Pl. IV. fig. 7) were found, chiefly in the liver, but sometimes in connexion with the intestine—occasionally in both places in the same individual. Rarely were there more than half a dozen in one cockle, and only in about 20 per cent. were they entirely absent. They seemed to be free, and being provided with cilia they moved about actively enough. The general outline of the body was oval, tapering anteriorly, but somewhat blunter posteriorly. There was some diversity in size, the largest being about ·8 mm. long, with a greatest width of ·38 mm. Small examples not exceeding ·2 mm. were occasionally observed.

Two crescentic eye-spots (fig. 7, *e.s.*) are present in front, and between and slightly anterior to them a pharynx is situated. Inside the sporocyst a number of globular cysts appear, usually from six to eight. Each cyst contains from two to four daughter-sporocysts (*d.s.*) in various stages of development. The youngest cysts, occurring generally near the body-wall of the sporocyst towards the anterior end, appear entirely undivided and contain small globular bodies. A somewhat older stage shows a division into two hemispheres. Later these take on the character of daughter-sporocysts, two eye-spots and cilia making their appearance. Towards the hinder end of the daughter-sporocyst four or five globules are seen similar to those mentioned above. Inside the cyst the minute sporocysts can be observed moving round and round, and on rupture of the parent they make their escape and swim about with considerable agility.

The relationship of these sporocysts to the other stages of Trematode larvæ found in the cockle is a matter of some difficulty. The occurrence of the sporocysts, containing cercariæ, in close proximity to the liver is somewhat suggestive of a connexion between these two stages at least.

* v. Linstow, Arch. f. Naturg. xliii. 1877, p. 183, pl. xiii. fig. 15.

† *Ibid.* fig. 14.

‡ Wedl, Wiener Sitzungsber. xxvi. 1857, pl. i. fig. 5.

§ *Cf.* Northumberland Sea-Fisheries Report, 1904, p. 82, where, in a note by Miss M. V. Lebour, B.Sc., what appears to be the same parasite is described, but in an imperfect manner.

‖ The sporocysts are also described in the same note.

No redia or other intermediate stage has as yet come under my observation.

Again, on examination of several other Lamellibranchiate mollusks from the neighbourhood of the Eden, I found in the mussel (*Mytilus edulis*) and *Mactra stultorum* the same encysted parasites in the foot. They were as numerous in the mussel as in the cockle, and occurred in almost every example; even in specimens measuring only 8 mm. as many as half a dozen cysts could be counted in the foot. In *Mactra* they were rarer. But in *Mytilus* and *Mactra* sporocysts did not occur in the mantle, in the mid-dorsal line, or in the liver. This would appear to be a proof that the sporocysts in the liver, and those containing cercariæ in the mid-dorsal line, are stages of the same parasite, or, at any rate, that they have no relation to the cysts in the foot.

The antecedent stages of both these parasites are as yet unknown. Examination of the mantle-cavity of the cockle and mussel displayed numerous Infusor-like animals of different kinds, some of which may prove to be the *Miracidium* larva *.

EXPLANATION OF PLATE IV.†

Fig. 1. Diagram of cockle (removed from valves), showing situation of sporocyst mass (*m.s.*). *l.*, liver; *a.a.*, anterior adductor; *p.a.*, posterior adductor; *r.*, rectum.

Fig. 2. Pressure preparation of sporocyst mass. *sp.*, the individual sporocysts; *cer.*, cercaria.

Fig. 3. The cercaria. *a.s.*, anterior sucker; *e.s.*, eyes; *ph.*, pharynx; *oes.*, œsophagus; *c.s.*, cuticular spines; *ex.*, excretory system; *div.*, intestinal diverticula; *k.s.*, globular cells; *p.s.*, posterior sucker; *ts.*, testis; *ex.p.*, excretory pore. Cuticular spines omitted.

Fig. 4. Cyst from foot of cockle, showing parasite coiled up inside. *a.s.*, anterior sucker; *c.s.*, ridge of spines; *ph.*, pharynx; *ex.*, excretory system; *p.s.*, posterior sucker; *ex.v.*, excretory vesicle; *c.*, capsule.

Fig. 5. Cercaria from foot of cockle. *a.s.*, anterior sucker; *c.s.*, ridge with spines; *ph.*, pharynx; *c.s.*, cuticular spines; *oes.*, œsophagus; *dig.*, intestinal diverticula; *p.s.*, posterior sucker; *f.t.*, tubule with flame-flagella; *ex.*, excretory system; *ex.v.*, excretory vesicle; *ex.p.*, excretory pore. Cuticular spines omitted.

Fig. 6. Adult from intestine of oyster-catcher. Lettering same as in fig. 5.

Fig. 7. Sporocyst from liver of cockle. *ph.*, pharynx; *e.s.*, eye-spots; *c.*, cilia; *a*, undivided cyst; *b*, cyst, later stage; *d*, cyst containing daughter-sporocysts; *d.s.*, daughter-sporocyst.

---

* I should like to note here that in the mantle-cavity of the cockle swarms of a species of Infusor of the genus *Trichodina* occurred. They were found both swimming about free and adhering to the mantle and foot.

† I have to thank my friend Mr. D. D. Craig, M.A., for preparing the drawings which accompany this paper.